BRITISH STANDARD

BS EN 61373:1999
IEC 61373:1999

Railway applications — Rolling stock equipment — Shock and vibration tests

The European Standard EN 61373:1999 has the status of a British Standard

ICS 17.160; 45.060.01

National foreword

This British Standard is the English language version of EN 61373:1999. It is identical with IEC 61373:1999.

The UK participation in its preparation was entrusted by Technical Committee GEL/9, Railway electrotechnical applications, to Subcommittee GEL/9/2, Rolling stock, which has the responsibility to:

- — aid enquirers to understand the text;
- — present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- — monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

Attention is drawn to the fact that CEN and CENELEC Standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement these international or European publications may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 40, an inside back cover and a back cover.

This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 June 1999

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 32563 6

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 61373

April 1999

ICS 45.060

English version

Railway applications
Rolling stock equipment
Shock and vibration tests
(IEC 61373:1999)

Applications ferroviaires
Matériel roulant
Essais de chocs et vibrations
(CEI 61373:1999)

Bahnanwendungen
Betriebsmittel von Bahnfahrzeugen
Prüfungen für Schwingen und Schocken
(IEC 61373:1999)

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 9/475/FDIS, future edition 1 of IEC 61373, prepared by IEC TC 9, Electric traction equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61373 on 1999-04-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2000-01-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2003-04-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annex ZA is normative and annexes A, B, C and D are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61373:1999 was approved by CENELEC as a European Standard without any modification.

CONTENTS

INTRODUCTION

This standard covers the requirements for random vibration and shock testing items of mechanical, pneumatic, electrical and electronic equipment/components (hereafter only referred to as equipment) to be fitted on to railway vehicles. Random vibration is the only method to be used for equipment/component approval.

The tests contained within this standard are specifically aimed at demonstrating the ability of the equipment under test to withstand the type of environmental vibration conditions normally expected for railway vehicles. In order to achieve the best representation possible, the values quoted in this standard have been derived from actual service measurements submitted by various bodies from around the world.

This standard is not intended to cover self-induced vibrations as these will be specific to particular applications.

Engineering judgement and experience is required in the execution and interpretation of this standard.

This standard is suitable for design and validation purposes; however, it does not exclude the use of other development tools (such as sine sweep), which may be used to ensure a predetermined degree of mechanical and operational confidence. To assist product design for compliance with this standard, guidance is given in annex B which allows comparison with alternative design methods.

The test levels to be applied to the item under test are dictated only by its location on the train (i.e. axle, bogie or body-mounted).

It should be noted that these tests may be performed on prototypes in order to gain design information about the product performance under random vibration. However, for attestation of testing purposes the tests have to be carried out on equipment taken from normal production.

RAILWAY APPLICATIONS – ROLLING STOCK EQUIPMENT – SHOCK AND VIBRATION TESTS

1 Scope

This International Standard specifies the requirements for testing items of equipment intended for use on railway vehicles which are subsequently subjected to vibrations and shock owing to the nature of railway operational environment. To gain assurance that the quality of the item is acceptable, it has to withstand tests of reasonable duration that simulate the service conditions seen throughout its expected life.

Simulated long-life testing can be achieved in a number of ways each having their associated advantages and disadvantages, the following being the most common:

a) amplification: where the amplitudes are increased and the time base decreased;

b) time compression: where the amplitude history is retained and the time base is decreased;

c) decimation: where time slices of the historical data are removed when the amplitudes are below a specified threshold value.

The amplification method as stated in a) above, is used in this standard and together with the publications referred to in clause 2; it defines the default test procedure to be followed when vibration testing items for use on railway vehicles. However, other standards do exist and may be used with prior agreement between the manufacturer and the customer. In such cases attestation of testing against this standard will not apply. Where service information is available comparison with the standard can be performed using the method outlined in annex A.

Whilst this standard is primarily concerned with railway vehicles on fixed rail systems, its wider use is not precluded. For systems operating on pneumatic tyres, or other transportation systems such as trolleybuses, where the level of shock and vibration clearly differ from those obtained on fixed rail systems, the supplier and customer can agree at the tender stage, the test levels. It is recommended that the frequency spectra and the shock duration/amplitude be determined using the guidelines set out in annex A. Items tested at levels outside those quoted in this standard can not be certified against the requirements of this standard.

An example of this is trolleybuses, whereby body-mounted trolleybus equipment could be tested in accordance with category 1 equipment referred to in the standard.

This standard applies to single axis testing. Multi-axis testing is outside the scope of this standard.

The test values quoted in this standard have been divided into three categories dependent only upon the equipment's location within the vehicle.

Category 1 Body mounted

<u>Class A</u> Cubicles, subassemblies, equipment and components mounted directly on or under the car body.

<u>Class B</u> Anything mounted inside an equipment case which is in turn mounted directly on or under the car body.

NOTE – Class B should be used when it is not clear where the equipment is to be located.

Category 2 Bogie mounted

Cubicles, subassemblies, equipment and components which are to be mounted on the bogie of a railway vehicle.

Category 3 Axle mounted

Subassemblies, equipment and components or assemblies which are to be mounted on the wheelset assembly of a railway vehicle.

NOTE – In the case of equipment mounted on vehicles with one level of suspension such as wagons and trucks, unless otherwise agreed at the tender stage, axle mounted equipment will be tested as category 3, and all other equipment will be tested as category 2.

The cost of testing is influenced by the weight, shape and complexity of the item under test. Consequently at the tender stage the supplier may propose a more cost effective method of demonstrating compliance with the requirements of this standard. Where alternative methods are agreed it will be the responsibility of the supplier to demonstrate to his customer or his representative that the objective of this standard has been met. If an alternative method of evaluation is agreed, then the item tested cannot be certified against the requirement of this standard.

This standard is intended to evaluate equipment which is attached to the main structure of the vehicle (and/or components mounted thereon). It is not intended to test equipment which forms part of the main structure. There are a number of cases where additional or special vibration tests may be requested by the customer, for example:

a) equipment mounted on, or linked to, items which are known to produce fixed frequency excitation;
b) equipment such as traction motors, pantographs, shoegear, suspension components and mechanical parts designed to transmit forces and/or torque, which may be subjected to tests in accordance with their special requirements, applicable to their use on railway vehicles. In all such cases the tests carried out should be dealt with by separate agreement at the tender stage;
c) equipment intended for use in special operational environments as specified by the customer.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-47:1982, *Basic environmental testing – Part 2: Tests – Mounting of components, equipment and other articles for dynamic tests including shock (Ea), bump (Eb) vibration (Fc and Fd) and steady state acceleration (Ga) and guidance*

IEC 60068-2-64:1993, *Environmental testing – Part 2: Test methods – Test Fh: Vibration, broadband random (digital control) and guidance*

3 Definitions

For the purpose of this standard the definitions given in IEC 60068-2-64 apply.

4 General

This standard is intended to highlight any weakness/error which may result in problems as a consequence of operation under environments where vibration and shock are known to occur in service on a railway vehicle. This is not intended to represent a full life test. However, the test conditions are sufficient to provide some reasonable degree of confidence that the equipment will survive the specified life under service conditions.

Compliance with this standard is achieved providing no mechanical damage or deterioration in performance occurs as a result of these tests.

The test levels quoted in this standard have been derived from environmental test data, as referred to in annex A. This information was submitted by organizations responsible for collecting environmental vibration levels under service conditions.

The following tests are mandatory for compliance with this standard:

Functional random test levels	These are the minimum test levels to be applied in order to demonstrate that the equipment under test is capable of functioning when subjected to conditions which are likely to occur in service, on railway vehicles. The degree of functioning shall be agreed between the manufacturer and the end user prior to tests commencing (see 6.3.2). Functional test requirements are detailed in clause 8. The functional tests are not intended to be a full performance evaluation under simulated service conditions.
Simulated long life test levels	This test is aimed at establishing the mechanical integrity of the equipment at increased service levels. It is not necessary to demonstrate ability to function under these conditions. Simulated long life testing requirements are detailed in clauses 9 and 10.
Shock testing	Shock testing is aimed at simulating rare service events. It is not necessary to demonstrate functionality during this test. It will however be necessary to demonstrate that no change in operational state occurs, and that no mechanical movement or damage takes place. These points shall be clearly demonstrated in the final test report.

5 Order of testing

A possible order of testing is as follows:

Vertical, transverse and longitudinal simulated long life testing by increased random vibration; followed by vertical, transverse and longitudinal shock testing; followed by transportation and handling (when identified/agreed) and finally by vertical, transverse and longitudinal functional random testing.

NOTE – Transportation and handling tests are not a requirement of this standard, and are therefore not included in this standard.

The order of testing may be altered to minimize re-jigging. The order of testing shall be recorded in the report. Performance tests in accordance with 6.3.3 shall be undertaken before and after simulated long life testing, during which time transfer functions will be taken for comparison purposes in order to establish if any changes have taken place as a result of the simulated long life testing.

The orientation and direction of excitation shall be stated in the test specification and included in the report.

6 Reference information required by the test house

NOTE 1 – Additional general information can be found in IEC 60068-2-64.

NOTE 2 – For general mounting of components refer to IEC 60068-2-47.

6.1 Method of mounting and orientation of equipment under test

The equipment under test shall be mechanically connected to the test machine by its normal means of attachment, including any resilient mount, either directly or by means of a fixture.

As the method of mounting can significantly influence the results obtained, the actual method of mounting shall be clearly identified in the test report.

Unless otherwise agreed it is preferred that the equipment shall be tested in its normal working orientation with no special precautions taken for the effects of magnetic interference, heat or any other factors, upon the operation and performance of the equipment under test.

Wherever possible, the fixture shall not have a resonance within the test frequency range. When resonances are unavoidable, the influence of the resonance on the performance of the equipment under test shall be studied and identified in the report.

6.2 Reference and control points

The test requirements are confirmed by measurements made at a reference point and, in certain cases, at control points, related to the fixing points of the equipment.

In the case of large numbers of small items of equipment mounted on to one fixture, the reference and/or the control points may be related to the fixture rather than to the fixing points of the equipment under test provided the lowest resonant frequency of the loaded fixture is above the upper test frequency limit.

6.2.1 Fixing point

A fixing point is a part of the equipment under test in contact with the fixture or vibration testing surface at a point where the equipment is normally fastened in service. If a part of the mounting structure is used as the fixture, the fixing points shall be taken as those of the mounting structure and not of the equipment under test.

6.2.2 Control point

A control point is normally a fixing point. It shall be as close as possible to the fixing point and in any case shall be rigidly connected to the fixing point. If four or less fixing points exist, each one is defined as a control point. The vibration at these points shall not fall below the specified minimum limits. All control points shall be identified in the test report. In the case of small items of equipment where the size, weight and complexity of the mechanical structure do not merit multipoint control, the report shall identify how many control points were used and their locations.

6.2.3 Reference point

The reference point is the single point from which the reference signal is obtained in order to confirm the test requirements, and is taken to represent the motion of the equipment under test. It may be a control point or a fictitious point created by manual or automatic processing of the signals from the control points.

For random vibration if a fictitious point is used, the spectrum of the reference signal is defined as the arithmetic mean at each frequency of the acceleration spectral density (ASD) values of the signals from all control points. In this case, the total r.m.s. value of the reference signal is equivalent to the root mean square of the r.m.s. values of the signals from the control points.

$$\text{Total r.m.s. value of the reference point} = \sqrt{\frac{\sum_{i=1}^{i=n_c} (r.m.s._i)^2}{n_c}}$$

where n_c is the number of control points.

The report shall state the point used and how it was chosen. It is recommended that for large and/or complex equipment a fictitious point is used.

NOTE – Automatic processing of the signals from the control points using a scanning technique to create the fictitious point is permitted for confirmation of the total r.m.s. acceleration. However, it is not permitted for confirmation of the ASD level without correcting for such sources of error as analyzer bandwidth, sampling time etc.

6.2.4 Response point (measuring points)

A response point is a specific location on the equipment under test at which data is gathered for the purpose of examining the vibration response characteristics of the equipment. This is done before commencing the tests detailed in this standard (see clause 7).

6.3 Mechanical state and functioning during test

6.3.1 Mechanical state

If the equipment under test has more than one mechanical condition in which it could remain for long periods when fitted to a railway vehicle, two mechanical states shall be selected for test purposes. At least one of the worst states shall be selected (for example, in the case of a contactor, the mechanical state which affords the least clamping pressure).

When more than one state exists, the equipment under test shall spend equal time in both states selected during vibration and shock testing; the levels of which are as specified in clauses 8 and 10 respectively.

6.3.2 Functional tests

If required, the functional tests shall be specified by the manufacturer and agreed between manufacturer and customer prior to commencement of the tests. They shall be carried out during the vibration tests at the levels stated in clause 8 of this standard.

Functional tests are aimed to verify the operational capability and are not to be confused with performance tests. They are only intended to demonstrate a degree of confidence that the equipment under test will perform in service.

NOTE 1 – Functional tests will not be conducted during shock testing unless previously agreed between the manufacturer and end user.

NOTE 2 – In the case where the functional tests are modified, then these have to be detailed in the report.

6.3.3 Performance tests

Performance tests shall be carried out prior to commencing, and on completion of all the tests specified. The performance test specification shall be defined by the manufacturer and shall include tolerance limits.

6.4 Reproducibility for random vibration tests

Random vibration signals are not repeatable in the time domain; no two similar length time samples from a random signal generator can be overlain and shown to be identical. Nevertheless it is possible to make statements about the similarity of two random signals and set tolerance bands on their characteristics. It is necessary to define a random signal in a way that ensures that, should the test be repeated at a later date, by a different test house or on a different item of equipment, then the excitation is of a similar severity. It should be noted that all the following tolerance boundaries include instrumentation errors but exclude other errors, specifically random (statistical) errors and bias errors. The measurements are taken at the control/reference point(s).

6.4.1 Acceleration spectral density (ASD)

The ASD shall be within ±3 dB (range ½ × ASD to 2 × ASD) of the specified ASD levels as shown in the appropriate figures 1 to 4. The initial and final slope should not be less than those shown in figures 1 to 4.

6.4.2 Root mean square value (r.m.s.)

The r.m.s. of the acceleration at the reference point over the defined frequency range shall be that specified in figures 1 to 4 ± 10 %.

NOTE – With respect to the low frequency content it may be difficult to obtain ±3 dB. In such cases it is only important for the test value to be noted in the report.

6.4.3 Probability density function (PDF)

Unless otherwise stated, for each response point the time series of the measured acceleration(s) shall have a distribution with a PDF which is approximately Gaussian and a crest factor (ratio of the peak to r.m.s. values) of at least 2,5.

NOTE – Figure 5 shows the tolerance bands of the cumulative PDF.

6.4.4 Duration

The total duration of exposure to the prescribed random vibration in each axis shall not be less than that specified (see 8.2 and 9.2).

6.5 Measuring tolerances

The vibration tolerances shall conform to 4.3 of IEC 60068-2-64.

6.6 Recovery

The initial and final measurements shall be taken under the same conditions (for example, temperature). If necessary a period of time after testing and before the final measurements shall be allowed, in order to enable the equipment under test to attain the same conditions as existed for the initial measurements.

7 Initial measurements and preconditioning

Before commencing any testing, the equipment shall be subjected to a performance test according to 6.3.3. Where the nature of such testing is outside the physical capability of the test house, the tests shall be conducted by the manufacturer who shall provide a statement that the item under test conformed with the performance tests prior to the vibration and shock testing identified in this standard. It is the responsibility of the manufacturer to define the location of the response points which shall be clearly identified in the report.

Transfer functions shall be calculated from the random signals taken from the reference point and response points, which shall be defined by the manufacturer. Where panels are removed for examination or instrumentation, they shall be replaced during the testing.

The transfer functions shall be taken under the test conditions specified in clause 8 for categories 2 and 3 equipment and in clause 9 for category 1 equipment.

The measurement shall aim to achieve a coherence of at least 0,9. If this is not possible, a minimum of 120 spectral averages (or 240 statistical degrees of freedom for linear averaging) shall be taken with 0 % overlap.

8 Random vibration test conditions

8.1 Test severity and frequency range

The equipment shall be tested with the relevant r.m.s. value and frequency range given in table 1. When the application orientation of equipment is unclear or unknown then the test shall be carried out in the three planes with the r.m.s. value given for the vertical plane.

Table 1 – Test severity and frequency range for functional random vibration tests

Category	Orientation	RMS m/s^2	Frequency range (see figure)
1 Class A Body mounted	Vertical Transverse Longitudinal	0,75 0,37 0,50	1
1 Class B Body mounted	Vertical Transverse Longitudinal	1,00 0,45 0,70	2
2 Bogie mounted	Vertical Transverse Longitudinal	5,4 4,7 2,5	3
3 Axle mounted	Vertical Transverse Longitudinal	38 34 17	4

NOTE – These test values are intended to represent typical service values as highlighted in annex A, and are the minimal test levels to be applied to the equipment under test. Where actual measured data exists the functional vibration test conditions listed below may be increased by using the method shown in annex A. The values quoted are considered as the minimum test levels to be applied to the equipment under test.

8.2 Duration of functional vibration tests

NOTE 1 – The object of this test is to demonstrate that the equipment under test is unaffected by the applied test levels which are representative of those expected in service.

NOTE 2 – It is envisaged that these tests would not normally take less than 10 min.

The duration of the functional vibration test shall be sufficient to allow all the specified functions to be completed.

8.3 Functioning during test

The functional tests agreed with the customer (see 6.3.2) shall be carried out during functional random vibration testing.

9 Simulated long life testing at increased random vibration levels

9.1 Test severity and frequency range

When the application orientation of equipment is unclear or unknown then the equipment shall be subjected to the vertical test levels of table 2 in all three planes.

Table 2 – Test severity and frequency range

Category	Orientation	RMS 5 h test period m/s²	Frequency range (see figure)
1 Class A Body mounted	Vertical Transverse Longitudinal	5,90 2,90 3,90	1
1 Class B Body mounted	Vertical Transverse Longitudinal	7,90 3,50 5,50	2
2 Bogie mounted	Vertical Transverse Longitudinal	42,5 37,0 20,0	3
3 Axle mounted	Vertical Transverse Longitudinal	300 270 135	4

9.2 Duration of accelerated vibration tests

All categories of equipment shall be subjected to a total conditioning time of 15 h. This shall normally be divided into periods of 5 h conditioning in each of three mutually perpendicular axes. If during the course of testing over heating of equipment is felt to be a problem, (i.e. vibration of rubber parts, etc.) it is permissible to stop the tests for a period of time in order to allow the equipment to recover. However, it must be noted that the total duration of 5 h vibration shall be achieved. If tests are stopped then this shall be stated in the report.

NOTE 1 – It is not necessary for equipment to function during this test.

NOTE 2 – It is possible by prior agreement to reduce the amplitude of vibration. However, it is essential that the duration of the test period be increased in accordance with the method shown in annex A. This is not a preferred option and should be limited to category 3 axle mounted equipment. When this method is used no attestation of testing may be issued as it is outside the scope of this recommendation.

10 Shock testing conditions

10.1 Pulse shape and tolerance

The equipment under test shall be subjected to a sequence of single half sine pulses each with a nominal duration of D and a nominal peak amplitude of A conforming to IEC 60068-2-27 (see figure 6 for values of D and A).

The transverse motion shall not exceed 30 % of the peak acceleration of the nominal pulse in the intended direction in accordance with IEC 60068-2-27.

Figure 6 shows pulse shape and tolerance limits.

10.2 Velocity changes

The actual velocity change shall be within ±15 % of the value corresponding to the nominal pulse shown in figure 6.

Where the velocity change is determined by integration of the actual pulse shown, it shall be evaluated over the integration time interval shown in figure 6.

10.3 Mounting

The equipment under test shall be connected to the test machine in accordance with 6.1.

10.4 Repetition rate

In order to allow the equipment under test to recover from any resonance effects sufficient time shall be allowed to elapse between the application of shocks.

10.5 Test severity, pulse shape and direction

Values are given in table 3.

Table 3 – Test severity, pulse shape and direction

Category	Orientation	Peak acceleration A m/s²	Nominal duration D ms
1 Class A and class B Body mounted	Vertical Transverse Longitudinal	30 30 50	30 30 30
2 Bogie mounted	All	300	18
3 Axle mounted	All	1 000	6
NOTE – See figure 6 for pulse shape details.			

10.6 Number of shocks

The 18 shocks (three positive and three negative in each of the three orthogonal planes) as specified in IEC 60068-2-27 shall be applied to the equipment. This test shall be repeated for each mechanical state as identified in 6.3.1.

10.7 Functioning during test

It is not necessary for the equipment to operate during tests. Nevertheless some equipment may have to keep integrity of its function and that shall be verified as requested by the manufacturer or the customer in the test specification except otherwise stated in the relevant product standard.

11 Transportation and handling

Where transportation and handling tests are specifically requested by the end user, they shall be in accordance with IEC 60068-2-27.

12 Final measurements

On completion of the tests, the equipment shall be subjected to a performance test according to 6.3.3. Owing to the nature of such testing, it may be outside the capability of the test house. In such cases, the tests will be conducted by the manufacturer who shall provide a statement that the item under test conformed with the performance tests after the vibration and shock testing identified in this standard.

Transfer functions shall be calculated from the random signals taken from the reference point and response points, which shall be defined by the manufacturer. Where panels are removed for examination or instrumentation, they shall be replaced during the testing.

The transfer functions shall be taken under the test conditions specified in clause 8 for categories 2 and 3 equipment and in clause 9 for category 1 equipment.

The measurement shall aim to achieve a coherence of at least 0,9. If this is not possible a minimum of 120 spectral averages (or 240 statistical degrees of freedom for linear averaging) with 0 % overlap, shall be taken.

Any changes in the transfer functions or other measurements shall be investigated and explained in the test report.

13 Acceptance criteria

On completion of all the tests the equipment shall be considered acceptable for attestation of testing when the following applies:

a) performance according to 6.3.3 remains within the defined limits;

b) function according to 6.3.2 remains within the defined limits;

c) visual appearance and mechanical integrity has not changed.

14 Report

Upon completion of all or part of the tests, final measurements and functional checks, the test house shall issue a comprehensive report to their customer. The report shall describe the execution of the tests and their effect on the equipment together with:

a) the summary which shall identify changes which have occurred during the tests. Serial numbers/identification shall be quoted;

b) details of the instrumentation and test procedures used, which shall be made available on request. They may be included in the report but this is not mandatory;

c) methods of mounting which shall be reported as identified in 6.1;

d) method and order of testing used. The report shall also include figures showing the location of all control and measuring positions;

e) functional tests carried out and values obtained pre-test and post-test;

f) results of tests from control and reference positions, together with observations against the set objectives and acceptance criteria. The report shall contain all the control point graphs which shall be in the format of figures 1 to 6. They shall also contain the tolerance bands in order to demonstrate that the tests remained within the tolerance limits stated in this standard;

g) all observations done when functional test during vibration and/or function verification during shock are required.

NOTE – Where special tests have been carried out which exceed the requirements of this standard they may be included in the report.

15 Attestation of testing

Attestation of testing shall include all of the following information:

- description of equipment tested;
- manufacturer's name;
- equipment type and issue/modification status;
- equipment serial number;
- test house report number;
- report date;
- product test specification.

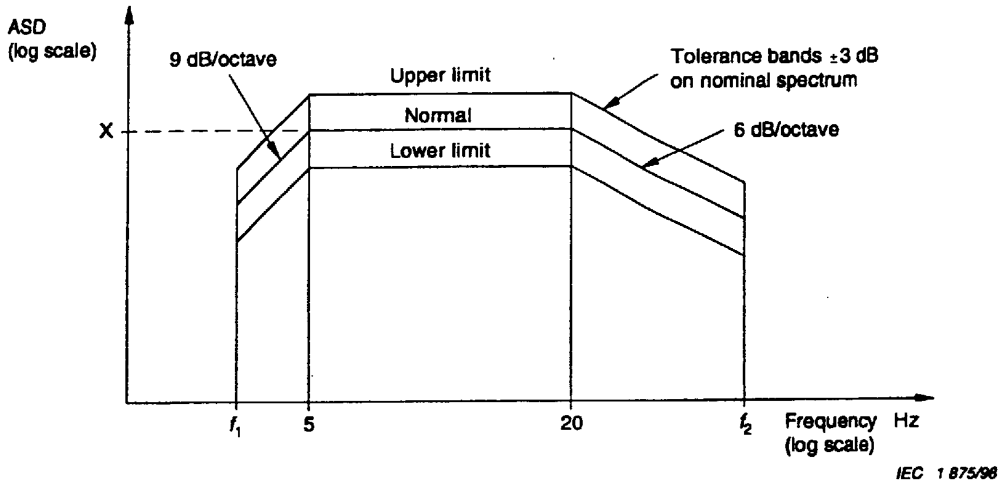
This attestation shall be signed by authorized representatives of the test house and the manufacturer.

NOTE – An example of a typical type test attestation is shown in annex D.

16 Disposal

The equipment, having satisfied the test objects and acceptance criteria may be refurbished, to a standard agreed between the manufacturer and the end user, and placed in operational service.

For traceability purposes, it is the responsibility of the manufacturer to identify clearly all items which have been tested in accordance with this standard.



when mass	<500 kg:	$f_1 = 5$ Hz	$f_2 = 150$ Hz
when mass	>500 kg<1 250 kg:	$f_1 = \frac{1\,250}{mass} \times 2$ Hz	$f_2 = \frac{1\,250}{mass} \times 60$ Hz
when mass	>1 250 kg:	$f_1 = 2$ Hz	$f_2 = 60$ Hz

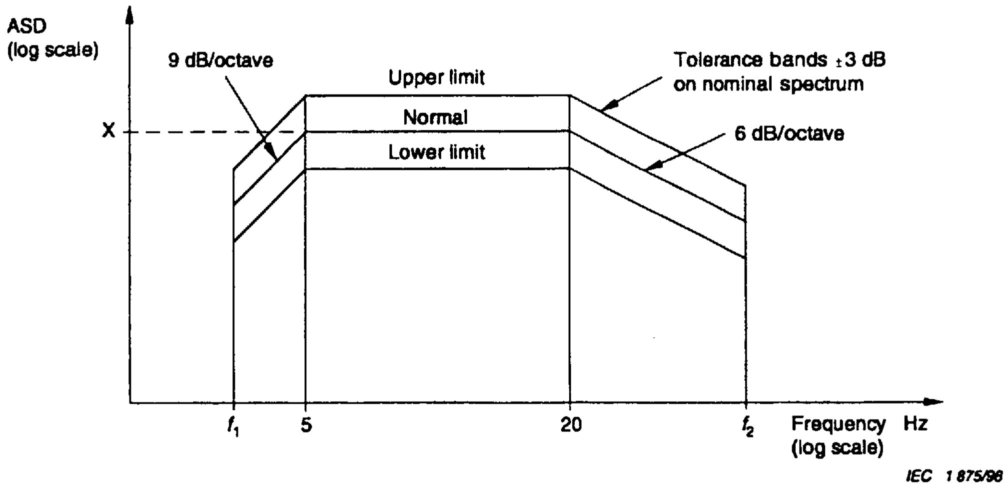
	Vertical	Transverse	Longitudinal
Functional test ASD level $(m/s^2)^2/Hz$	0,0164	0,0041	0,0073
RMS value m/s^2 5 Hz to 150 Hz	0,75	0,37	0,50
Long life test ASD level $(m/s^2)^2/Hz$	1,034	0,250	0,452
RMS value m/s^2 5 Hz to 150 Hz	5,9	2,9	3,9

NOTE 1 – For items with test frequencies less than 5 Hz the r.m.s. levels will be higher than those quoted above.

NOTE 2 – For items with test frequencies less than 150 Hz the r.m.s. levels will be lower than those quoted above.

NOTE 3 – If frequencies above f_2 are known to exist they may be included, the amplitude being established by extending the 6 dB/octave decay line until it intersects the maximum frequency required. In such cases the r.m.s. levels will be increased.

Figure 1 – Category 1 – Class A – Body-mounted ASD – spectrum



when mass	<500 kg:	$f_1 = 5$ Hz	$f_2 = 150$ Hz
when mass	>500 kg<1 250 kg:	$f_1 = \frac{1\,250}{\text{mass}} \times 2$ Hz	$f_2 = \frac{1\,250}{\text{mass}} \times 60$ Hz
when mass	>1 250 kg:	$f_1 = 2$ Hz	$f_2 = 60$ Hz

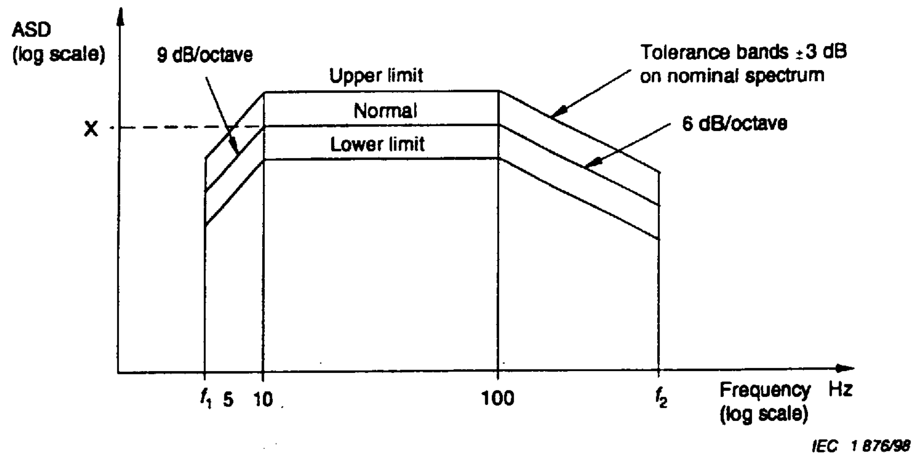
	Vertical	**Transverse**	**Longitudinal**
Functional test ASD level $(m/s^2)^2/Hz$	0,0298	0,0060	0,0144
RMS value m/s^2 5 Hz to 150 Hz	1,00	0,45	0,70
Long life test ASD level $(m/s^2)^2/Hz$	1,857	0,366	0,901
RMS value m/s^2 5 Hz to 150 Hz	7,9	3,5	5,5

NOTE 1 – For items with test frequencies less than 5 Hz the r.m.s. levels will be higher than those quoted above.

NOTE 2 – For items with test frequencies less than 150 Hz the r.m.s. levels will be lower than those quoted above.

NOTE 3 – If frequencies above f_2 are known to exist they may be included, the amplitude being established by extending the 6 dB/octave decay line until it intersects the maximum frequency required. In such cases the r.m.s. levels will be increased.

Figure 2 – Category 1 – Class B – Body-mounted – ASD spectrum



when mass	<100 kg:	$f_1 = 5$ Hz	$f_2 = 250$ Hz
when mass	>100 kg<250 kg:	$f_1 = \frac{250}{\text{mass}} \times 2$ Hz	$f_2 = \frac{250}{\text{mass}} \times 100$ Hz
when mass	>250 kg:	$f_1 = 2$ Hz	$f_2 = 100$ Hz

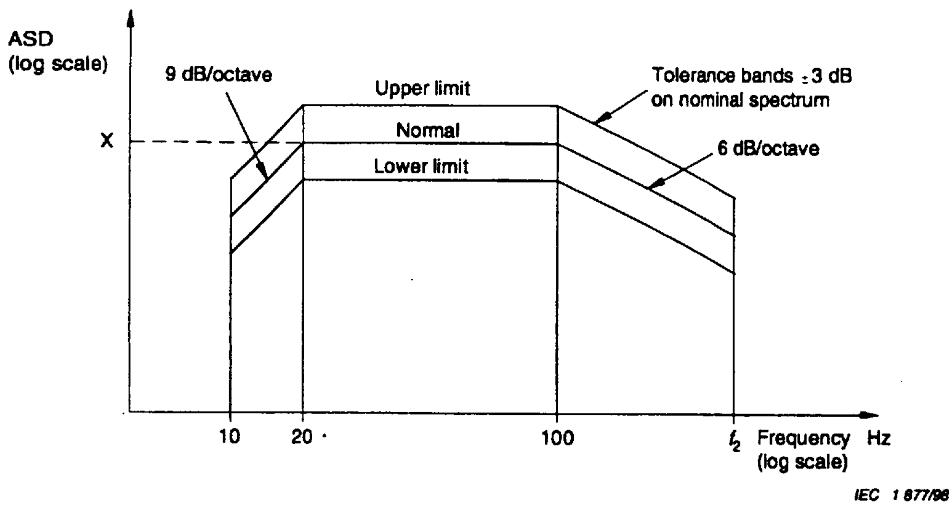
	Vertical	**Transverse**	**Longitudinal**
Functional test ASD level $(m/s^2)^2/Hz$	0,190	0,144	0,0414
RMS value m/s^2 5 Hz to 250 Hz	5,4	4,7	2,5
Long life test ASD level $(m/s^2)^2/Hz$	11,83	8,96	2,62
RMS value m/s^2 5 Hz to 250 Hz	42,5	37,0	20,00

NOTE 1 – For items with test frequencies less than 5 Hz the r.m.s. levels will be higher than those quoted above.

NOTE 2 – For items with test frequencies less than 250 Hz the r.m.s. levels will be lower than those quoted above.

NOTE 3 – If frequencies above f_2 are known to exist they may be included, the amplitude being established by extending the 6 dB/octave decay line until it intersects the maximum frequency required. In such cases the r.m.s. levels will be increased.

Figure 3 – Category 2 – Bogie mounted – ASD spectrum



when mass <50 kg: $f_2 = 500$ Hz

when mass >50 kg<125 kg: $f_2 = \frac{125}{\text{mass}} \times 200$ Hz

when mass >125 kg: $f_2 = 200$ Hz

	Vertical	Transverse	Longitudinal
Functional test ASD level $(m/s^2)^2/Hz$	8,74	7,0	1,751
RMS value m/s^2 10 Hz to 500 Hz	38	34	17
Long life test ASD level $(m/s^2)^2/Hz$	545,2	441,2	110,3
RMS value m/s^2 10 Hz to 500 Hz	300	270	135

NOTE 1 – For items with test frequencies less than 500 Hz the r.m.s. levels will be lower than those quoted above.

NOTE 2 – If frequencies above f_2 are known to exist they may be included, the amplitude being established by extending the 6 dB/octave decay line until it intersects the maximum frequency required. In such cases the r.m.s. levels will be increased.

Figure 4 – Category 3 – Axle mounted – ASD spectrum

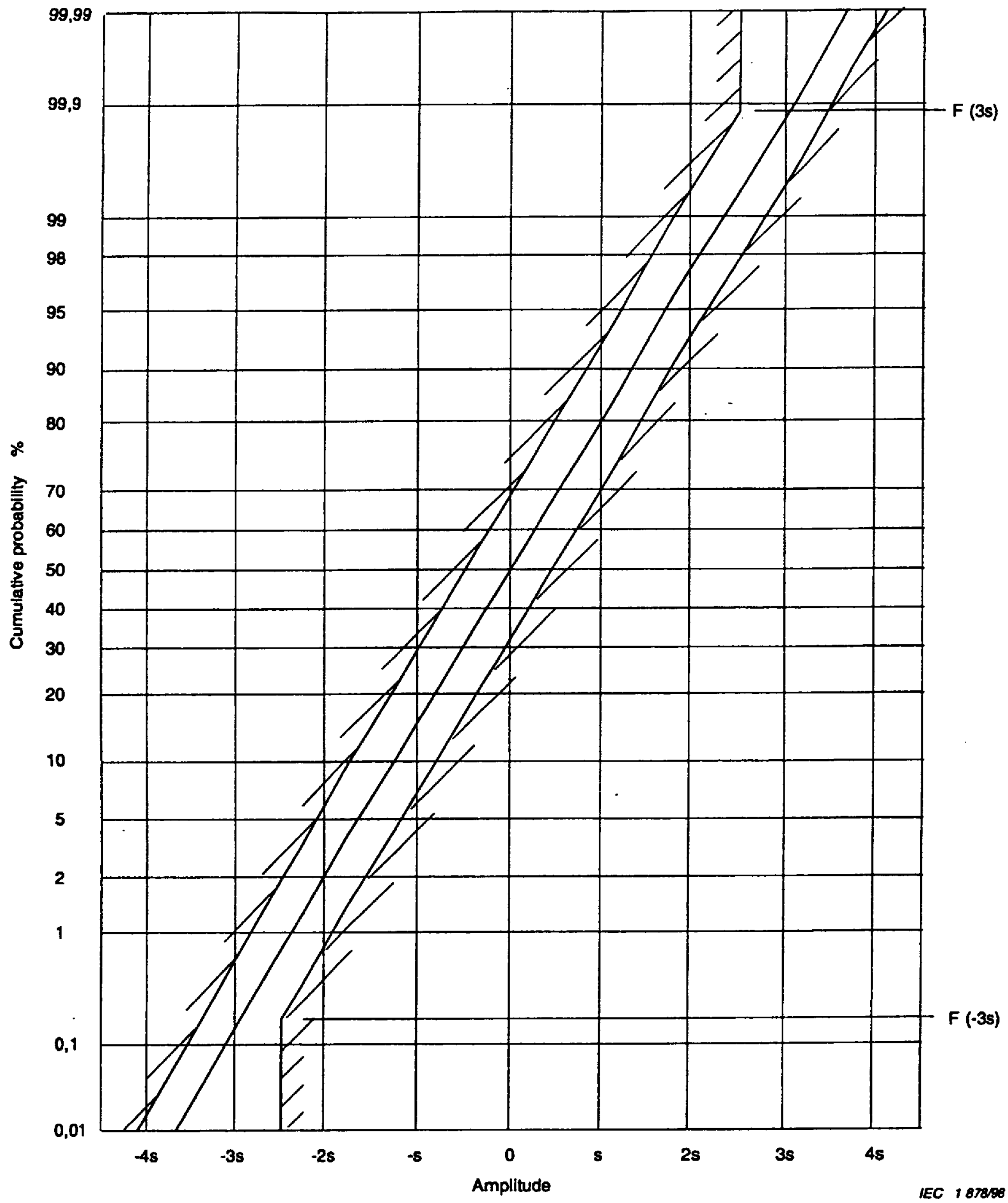
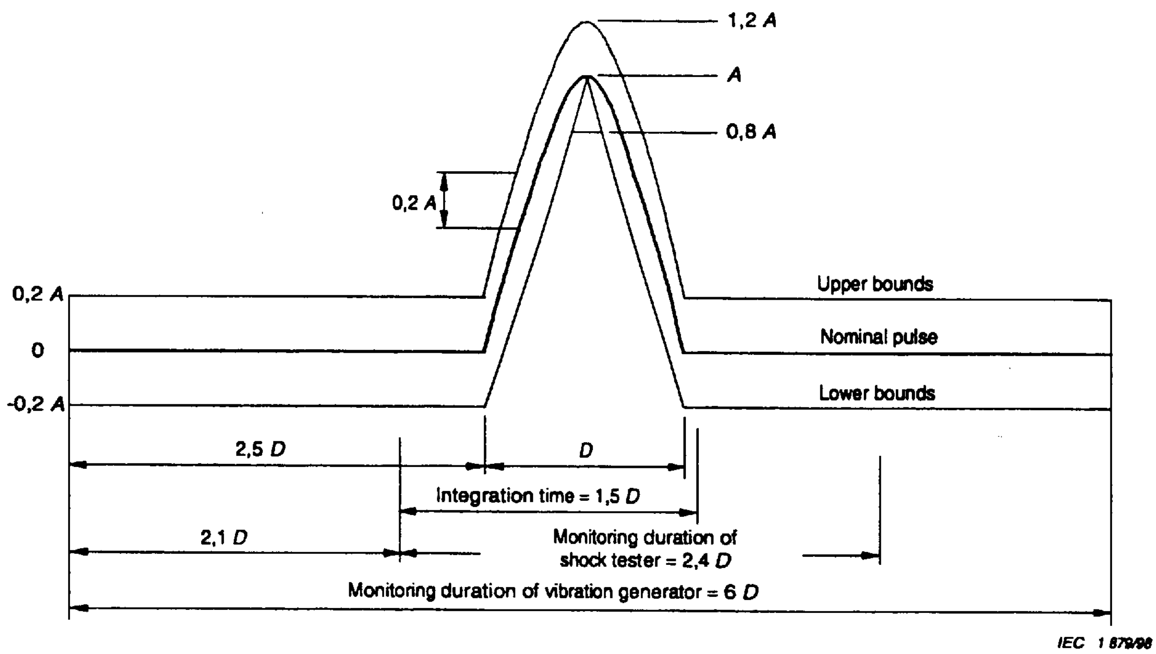


Figure 5 – Cumulative PDF tolerance bands



Category	Orientation	Peak acceleration A (m/s²)	Nominal duration D (ms)
1 Class A and class B Body mounted	Vertical Transverse Longitudinal	30 30 50	30 30 30
2 Bogie mounted	All	300	18
3 Axle mounted	All	1 000	6
NOTE – Some category 1 equipment intended for specific applications may require additional shock testing with peak accelerations A of 30 m/s² and duration D of 100 ms. In such cases these test levels should be requested and agreed prior to testing.			

Figure 6 – Shock test tolerance – Bands half sine pulse

Annex A
(informative)

Explanation of service measurements, measuring positions, methods of recording service data, summary of service data, and method used to obtain random test levels from acquired service data

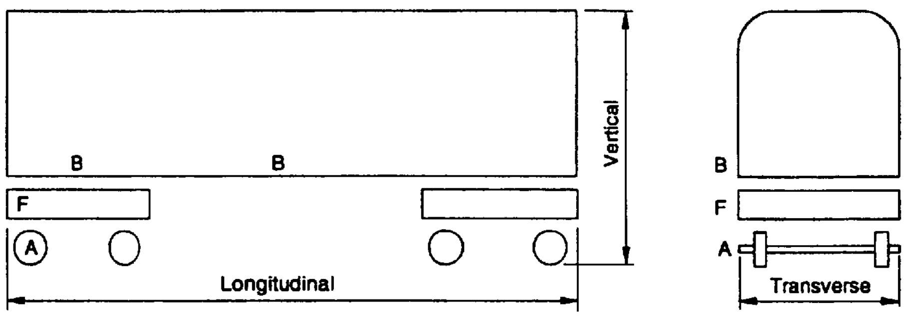
Rail vehicle shock and vibration varies depending on vehicle speed, rail/track conditions and other environment factors. To assess whether equipment attached to rail vehicles will perform satisfactorily for many years without failure, a design/test specification is required.

To establish a realistic test specification it was necessary to obtain measured service data and base test levels on this data. The following data and means are used to obtain it:

- Standard measuring positions used for axle, bogie and body-mounted categories (see A.1).
- Service data obtained from rail operators and equipment manufacturers utilizing a two-page questionnaire (see A.2).
- Summarized service data obtained (see A.3).
- Method used to obtain random test levels from the acquired service data (see A.4).
- Test levels obtained from service data using the method in A.4 (see A.5).

NOTE – When service data is available for the actual rail vehicles/network, test levels may be calculated using the method in figure A.2.

A.1 Standard measuring positions used for axle, bogie and body-mounted categories



A = Axle measuring position for vertical, transverse and longitudinal axes

F = Frame (bogie) measuring position for vertical, transverse and longitudinal axes

B = Body measuring position for vertical, transverse and longitudinal axes

Figure A.1 – Standard measuring positions used for axle, bogie (frame) and body

A.2 Service data obtained from rail operators and equipment manufacturers utilizing a two-page questionnaire

For each measuring position table A.1 should be completed.

Table A.1 – Environment data acquisition summary of the test parameters/conditions

Measurement position.......................... **Measurement direction**........................	
Test parameter/Condition (Question)	Comments (Answer)
General	
1 Reason for measuring vibration levels	....
2 Location of railway system	....
3 Type of vehicle measured	....
4 Special test or normal service	....
5 Vehicle speed	....
Main conditions	
6 Weather conditions (°C, % RH, rain, snow)	....
7 Axle loading of vehicle measured	....
8 Type of rail (UIC grade)	....
9 Rail foundation (sleepers, ballast)	....
10 Type of rail jointing (welded, jointed)	....
Additional conditions	
11 Wheel condition, profile, conicity	....
12 Rail condition (vertical r.m.s. amplitude)	....
13 Length of track used for measurements	....
14 Number and radius of bends	....
15 Number of crossings and points	....
16 Other exclusive events (bridges, tunnels)	....
17 Configuration of train and total mass	....
18 Tractive effort (drive vehicles only)	....
Recording	
19 Type of recording (FM, DR, PCM, DAT)	....
20 Frequency range (lower and upper)	....
21 Amplitude range (maximum and minimum)	....

Table A.1 *(concluded)*

Test parameter/Condition (Question)	Comments (Answer)
Time domain analysis	
22 Bandwidth of time domain analysis	....
23 Sampling frequency	....
24 Total number of samples or total time of all records	....
25 Max. acceleration (m/s^2, positive)	....
26 Min. acceleration (m/s^2, negative)	....
27 RMS value	....
28 Amplitude resolution	....
29 RMS m/s^2 based on the density function	....
Frequency analysis (Recommended bandwidth 500 Hz body; 500 Hz bogie and 500 Hz axle)	
30 Band width of frequency analysis/cut off frequency of anti-aliasing filter	....
31 Sampling frequency of corresponding time record	....
32 Frequency resolution (delta f) or number of frequency lines	....
33 Number of samples at data acquisition (block length)	....
34 Lower frequency limit	....
35 Type of time window and record length at acquisition/analysis	....
36 Number of averages (time records)	....
37 Overlap ($0 \le 0_f < 1$) and total number of samples	....
38 ADC resolution (dynamic range)	....
39 The inherent noise level of the instrumentation	....
40 Total r.m.s. m/s^2 based on PSD	....
Graphs required	
41 Power spectral density spectrum for frequency domain analysis	....
42 Probability density distribution for time domain analysis	....

A.3 Summarized service data obtained

See table A.2.

Table A.2 – Summary of the r.m.s. acceleration levels obtained from the questionnaire

Category	Max. Level m/s^2 r.m.s.	Average level m/s^2 r.m.s.	Standard deviation	Number of values
1				
Body vertical	1,24	0,49	0,26	19
Body transverse	0,43	0,29	0,08	15
Body longitudinal	0,82	0,30	0,20	8
2				
Bogie vertical	7,0	3,1	2,3	14
Bogie transverse	7,0	3,0	1,7	10
Bogie longitudinal	4,1	1,2	1,3	9
3				
Axle vertical	43	24	14	19
Axle transverse	39	20	14	17
Axle longitudinal	20	11	6	9
NOTE – Use method shown in A.4 to obtain the test levels in A.5.				

A.4 Method used to obtain random test levels from the acquired service data

In order to reduce the test time the increased amplification method has been chosen for this standard. To perform a simulated long life random vibration test it has been assumed that the damage is proportional to the number of cycles multiplied by the stress level to a power:

$$\text{Dommage} = \alpha.\sigma^m N_f$$

where

N_f is the number of cycles;

σ is the stress level;

m is the power (typically 3 to 9).

This relationship has been related to acceleration levels, and the assumption that the service life and test life both equal a constant. Thus:

$$T_s A_s^m = T_t A_t^m$$

where

T_s is the service life/time;

T_t is the test time;

A_s is the service acceleration;

A_t is the test acceleration.

Transposing the above equation in terms of the ratio of acceleration gives:

$$\frac{A_t}{A_s} = \left(\frac{T_s}{T_t}\right)^{1/m}$$

therefore an acceleration ratio = a time factor:

$$\text{Time factor} = \left(\frac{T_s}{T_t}\right)^{1/m}$$

Therefore when

T_s = 25 % normal life
= 25 years life × 300 days/year × 10 hours/day × 25%
= 18 750 hours service time

T_t = 5 h test time

m = 4 (typical for metals)

$$\text{acceleration ratio} = \left(\frac{18750}{5}\right)^{1/4} = 7{,}83$$

For the purpose of this specification an environmental survey was performed. The data obtained has been compiled as r.m.s. levels and the variation in level as a standard deviation. See table A.2.

Category 1. Body Class B

Functional random test level = average service level + 2 standard deviations.

All other categories

Functional random test level = average service level + 1 standard deviation.

Simulated long life random test level = functional random test level × acceleration ratio

(See table A.3 for calculated test values.)

A.5 Test levels obtained from service data using the method in A.4

See table A.3.

Table A.3: Test levels obtained from service data using the method shown in A.4.

RMS acceleration levels in m/s²				
Category	**Functional RTL**		**Simulated long life RTL**	
	Class A	Class B	Class A	Class B
1				
Body vertical	0,75	1,00	5,9	7,9
Body transverse	0,37	0,45	2,9	3,5
Body longitudinal	0,50	0,70	3,9	5,5
2				
Bogie vertical	5,4		42,5	
Bogie transverse	4,7		37,0	
Bogie longitudinal	2,5		20,0	
3				
Axle vertical	38		300	
Axle transverse	34		270	
Axle longitudinal	17		135	

AS = Average service level

STD = Standard deviation

RTL = Random test level

FRTL = Functional random test level

SLLRTL = Simulated long life random test level

Class A = Category 1. Body-mounted equipment directly connected to car body structure

Class B = Category 1. Assemblies/components mounted within equipment connected directly to the car body structure.

Example: Calculation of test level using method A.4.

Body vertical

AS	=	0,49 (from table A.2)		
STD	=	0,26		
FRTL	=	AS + STD	= 0,75	Class A
SLLRTL	=	FRTL x Acceleration ratio	= 5,90	Class A

Annex B
(informative)

Guidance for deriving design levels from random vibration test data

B.1 Introduction

In the course of designing it is necessary to ensure that measures are taken to prevent the equipment/components failing during the vibration test or subsequently under normal service operation.

This annex provides equations for calculating vibration excitation amplitudes for design calculations. It also provides guidance on how to select random input values from the standard. At the end a worked example is presented and finally the fundamental equations are given in general form. Equations for approximate calculations in this annex have been derived using the single degree of freedom (SDOF) system.

Therefore it is the responsibility of the design engineer to select critical modes of vibration (SDOFs) to contribute in the evaluation of the mechanical integrity of the design.

Calculation procedures described in this annex are informative and are not to be considered as contractual requirements.

The evaluation of mechanical strength always demands a certain degree of engineering judgement of which both the supplier and the purchaser should be fully aware. This annex does not preclude the use of additional investigations for design purposes in order to cover specific contract or environmental requirements.

B.2 Object

When calculating mechanical strength, information relating to the degree of vibration to which the equipment is likely to be subjected during service operation is essential. In the absence of such information, this guidance provides alternative methods of deriving design vibration excitation data in compliance with this standard. This will enable the design engineer to calculate stress, force or acceleration responses in order to establish fatigue damage. However, it is not within the scope of this standard to deal with particular design methods.

Shock calculations are not treated in this annex, but it is recommended that the design engineer consider the shock excitation levels in this standard.

B.3 Definitions

The *crest factor* is known as the ratio of peaks to r.m.s. value of a vibration in the time domain.

Fatigue damage process refers to cumulative damage effects inside the equipment/components, induced by vibration forces acting on its fixing points.

Magnitude design refers to the maximal allowable vibration response effects (for example, exceeding may lead to damage or malfunction) of the equipment/components.

Shock design refers to maximal allowable transient response effect (for example, exceeding may lead to damage or malfunction) of the equipment/components.

The *Single degree of freedom* system (SDOF) is known as a single mass-spring/damper-system and can be described by a single second order differential equation.

B.4 Symbols

$A_{d(ft)}$	Fatigue damage stationary sine vibration excitation amplitude of design model at resonance (m/s^2)
$A_{d(mg)}$	Magnitude based stationary sine vibration excitation amplitude of design model at resonance (m/s^2)
ASD_{25}	Excitation acceleration spectral density at test, selected from figures 1 to 4 in this standard, indicating 25 % of life ((m/s^2)^2/Hz)
ASD_{100}	Excitation acceleration spectral density in design for 100 % of life ((m/s^2)^2/Hz)
Cf_t	Crest factor used at test
f	Resonance frequency of equipment/components considered as a SDOF system (Hz)
N_d	Number of response cycles for an SDOF system in design (cs)
N_{ll}	Number of response cycles for an SDOF system at life limit (the point on the S – N curve where it often is considered flat and equal to the endurance limit σ_{el}) (cs)
v	Peak/r.m.s. – response value of an SDOF system
v_l	Lower bounds of v
v_u	Upper bounds of v
Q	$1/(2\xi)$ = amplification at resonance
T_{rt}	Random test duration (s)
ξ	Fraction of critical damping
σ_{el}	Endurance limit (Pa)

B.5 Assumptions

The equations in this annex are constituted under the following assumptions:

a) The *fatigue damage* sine vibration excitation amplitude $A_{d(ft)}$ (m/s^2)of equation (B.8.1) gives rise to the same effect on the fatigue damage process in design as the corresponding random vibration excitation level, ASD_{100} ((m/s^2)^2/Hz), when exciting the equipment/ component considered as an SDOF system at each resonance of interest.

b) The *magnitude* based sine vibration excitation amplitude $A_{d(mg)}$ (m/s^2) equation (B.8.2 – the 3,0 σ approach) gives rise to the same maximum response amplitude at each resonance of interest in so far as the corresponding random vibration response is 3,0 times its r.m.s. value when the crest factor of the excitation is limited to 2,5.

   NOTE – The 3,0 σ approach refers to a limitation of the random vibration acceleration response level at test to a crest factor of 3,0. See also B.6.

c) The dynamic properties of the equipment/components are fairly linear.

d) The ratio between the weight of the equipment and its supporting structure is so small that dynamic interaction effects can be neglected.

e) There exist one or several dominant resonance frequencies of the equipment/component.

f) The fatigue damage process is based on the Miner damage model.

g) The incremental fatigue damage of one load cycle is proportional to the fourth power (m = 4) of the response amplitude of an SDOF system.

h) An endurance limit σ_{el} (Pa) for N_{ll} cycles does exist.

i) The influence of the crest factor on the fatigue damage process is neglected, which will lead to some conservatism (less than 5 % for crest factors claimed in this standard).

j) The random vibration response amplitudes of the SDOF system is assumed to be Rayleigh distributed.

B.6 Design procedures

There are several methods available in design to calculate relevant vibration parameters. The procedure preferred here is based on any relevant user defined dynamic model, excited by vibration quantities derived from the relevant ASD spectrum for simulated long life testing (5 h, 25 % of life), quoted in this standard, which in turn have been derived from service data according to annex A.

It is also recommended that the design engineer conduct shock calculations, considering shock response spectra according to IEC 60068-2-27, annex B, together with shock input excitation data selected from this standard.

B.6.1 Design conditions

In evaluating mechanical strength, the design engineer should consider both testing and service operation. The design conditions covered by this guidance correspond primarily to test conditions. The guidance provides vibration excitation levels to allow for evaluation of both fatigue and magnitude design.

The *fatigue damage* process is covered by the vibration excitation levels derived from the relevant test ASD spectrum for simulated long life testing, selected from this standard (scaled to cover 100 % of life) and should be evaluated against fatigue damage criteria.

The *magnitude* based design is to be evaluated with respect to maximum response amplitudes in test. These calculations will cover the eventual severities that occur due to increases of amplitude in the random vibration test caused by decrease of the time base. However, this excitation level will not necessarily reflect the real service situation.

The magnitude value of the exciting random vibration in test is defined by its r.m.s. value and the actual crest factor used by the testing machine. This crest factor must be at least 2,5 according to this standard. The design engineer should thus be cautious about the actual crest factor used at test. Significant higher crest factors than 2,5 will call for compensation of the magnitude design level accordingly when considering design against test requirements. Furthermore, the crest factor of the response, referred to in this guidance (see equation B.8.2 and B.5), tends to become higher than the crest factor of the test excitation (see equation B.10.2).

NOTE – That is, if the crest factor of the test excitation is known to be 2,5, the magnitude based sine design excitation should preferably be calculated to meet 3,0 times the r.m.s. value of the test response, as in this guidance.

In railway service operation, there exists a variety of vibration, bump and shock amplitudes. The crest factor may therefore be considerably higher than 2,5 and the magnitude value of the vibration in service operation is not easily definable.

B.7 Exact method of deriving design excitations from this standard

Random test excitation levels, transformed to random design excitation levels, are recommended for design, if the design engineer has access to computational tools for this kind of analysis.

B.7.1 Fatigue calculations by use of random excitation

ASD_{25} levels, which are equal to long life test levels, are selected from relevant figures 1 to 4 of this standard. Design ASD_{100} spectra for the *fatigue damage process* calculations expressed in $(m/s^2)^2/Hz$ are then obtained from:

$$ASD_{100} = 2 \times ASD_{25}; \qquad \text{(B.7.1)}$$

The factor 2 compensates for an increase of damage from 25 % of life during test to 100 % in design ($ASD_{100} = ASD_{25}\sqrt{4}$).

B.7.2 Magnitude calculations by use of random excitation

Vibration levels for magnitude based stress, force or acceleration calculations in design expressed in $(m/s^2)^2/Hz$ are trivially obtained as:

$$ASD_{25} \qquad \text{(B.7.2)}$$

B.8 Approximate methods of deriving design excitations from this standard

Considering the assumptions mentioned in B.5, approximate sine design excitation amplitudes may be used as an alternative to random excitation.

B.8.1 Fatigue calculations by use of sine excitation

Approximate fatigue damage process sine vibration excitation amplitude $A_{d(ft)}$ expressed in m/s² is obtained from *

$$A_{d(ft)} = 1,7 \left[\sqrt{(\pi/2) \times f \times ASD_{100}/Q}\right] \times [T_{rt}/(N_{ll}/f)]^{(1/4)} \qquad \text{(B.8.1)}$$

B.8.2 Magnitude calculations by use of sine excitation

Approximate magnitude based sine vibration excitation amplitude $A_{d(mg)}$ expressed in m/s² is obtained from * (the 3,0σ approach):

$$A_{d(mg)} = 3,0 \times \sqrt{(\pi/2) \times f \times ASD_{25}/Q} \qquad \text{(B.8.2)}$$

B.9 Example

Problem

A component is mounted into a cubicle installed under a train. The cubicle itself is directly mounted to the main structure of the car body and is exposed to vibration environment covered by this standard. Calculate corresponding design amplitudes of exciting acceleration in the vertical direction.

B.9.1 Exact method

Solution

Select random test vibration test data for *Category 1 – Class B – Body-mounted equipment (vertical)* from figure 2 of this standard. Select *ASD* – level (read normal level) and substitute into equation (B.7.1) in order to obtain *design ASD* spectrum level for *fatigue* damage calculations:

$$ASD_{100} = 2 \times 1,9 = 3,8 \ (\text{m/s}^2)^2/\text{Hz}$$

(Corresponding total *fatigue design* r.m.s. – value: r.m.s.$_d$ = $7,9 \times \sqrt{2} = 11,2$ m/s².)

Selected values are directly suitable for *magnitude* based calculations according to (B.7.2):

$$ASD_{25} = 1,9 \ (\text{m/s}^2)^2/\text{Hz}$$

* General form of the equation is given in B.10.

B.9.2 Approximate method

Solution

Select random *test* vibration data for *Category 1 – Class B – Body mounted equipment (vertical)* from figure 2 of this standard (read normal level). Calculate design ASD_{100} spectrum (see B.9.1) and assume input data as follows:

$$T_{rt} = 5 \text{ h} = 18\,000 \text{ s};\ N_{II} = 10^7;\ Q = 10 \text{ cs};\ f = 20 \text{ Hz}$$

Substitute into equation (B.8.1) to obtain the corresponding *design* sine amplitude for *fatigue damage* calculations, $A_{d(ft)}$:

$$A_{d(ft)} = 1{,}7 \times [\sqrt{(\pi/2) \times 20 \times 3{,}8/10}\,] \times [\,5 \times 3\,600/(10^7/20)]^{(1/4)} = 2{,}6 \text{ m/s}^2$$

Substitute ASD_{25} level into equation (B.8.2) to obtain the corresponding design sine amplitude for *magnitude design*, $A_{d(mg)}$:

$$A_{d(mg)} = 3{,}0 \times \sqrt{(\pi/2) \times 20 \times 1{,}9/10} = 7{,}33 \text{ m/s}^2$$

Check the ratio of *magnitude* at test to amplitude for *fatigue damage* calculations in design:

$$A_{d(mg)}/A_{d(ft)} = 7{,}33/2{,}56 = 2{,}86$$

Thus in design calculation for mechanical strength in compliance with this standard, the component in the cubicle under the train is considered to be excited by a continuous sine vibration level with an amplitude of 2,6 m/s^2 to simulate the fatigue process. Similarly the maximum response level during test is simulated by a sine excitation amplitude of 7,33 m/s^2, which is 2,86 times higher in this case. See table B.1.

Table B.1 gives exciting design levels of sample problem including extension to all three directions.

Table B.1 – Exciting design levels of sample problem including extension to all three directions

Category 1 – Class B – Body-mounted (ξ = 0,05 => q = 10) Design excitation levels												
Frequency f Hz	Random (B.7.1) ASD_{100} (m/s^2)^2/Hz			Random (B.7.2) ASD_{25} (m/s^2)^2/Hz			Sine (B.8.1) $A_{d(ft)}$; N_{II} = 10^7 cs m/s^2			Sine (B.8.1) $A_{d(mg)}$; 3,0 σ m/s^2		
	Vert.	Trans.	Long.	Vert.	Trans.	Long.	Vert.	Trans.	Long.	Vert.	Trans.	Long.
20	3,8	0,74	1,8	1,9	0,3	0,90	2,56	1,13	1,76	7,33	3,23	5,04

B.10 General form of equations used for deriving approximate design excitation

The simplified forms of these equations are given in B.8.

B.10.1 Fatigue calculations

Approximate fatigue damage process sine vibration excitation amplitude (m/s^2) s generally obtained from:

$$A_{d(ft)} = [\sqrt{(\pi\ /2) \times f \times ASD_{100}\ /Q}\,] \times [T_{rt} / (N_{ll} / f)]^{(1/m)} [\int_{v1}^{vu} v^{(m+1)} \times e^{-v2/2}\, \partial v^{(1/m)}] \quad \text{(B.10.1)}$$

The first term in equation (B.10.1) represents the r.m.s. response amplitude (m/s^2) of an SDOF – system, divided by Q, when excited by a broad band random vibration input, selected from the flat part of the relevant ASD spectrum for simulated long-life testing in this standard (scaled to cover 100 % of life).

The second term is a quantity due to difference in random test duration, T_{rt} (sec), and time to achieve N_{ll} (cs) at f (Hz) in design.

The third term is a quantity proportional to the integrated weight of all cycles participating in the fatigue process, assuming Rayleigh distribution of the SDOF system response amplitudes.

The factor m is a power depending on the slope of the S – N – curve (see annex A) and which is chosen to m = 4 in this standard.

B.10.2 Magnitude calculations

Approximate magnitude based sine vibration excitation amplitude (m/s^2) is generally obtained from:

$$A_{d(mg)} = (CF_t + 0{,}5) \times [\sqrt{(\pi\ /2) \times f \times ASD_{25}\ /Q}\,] \quad \text{(B.10.2)}$$

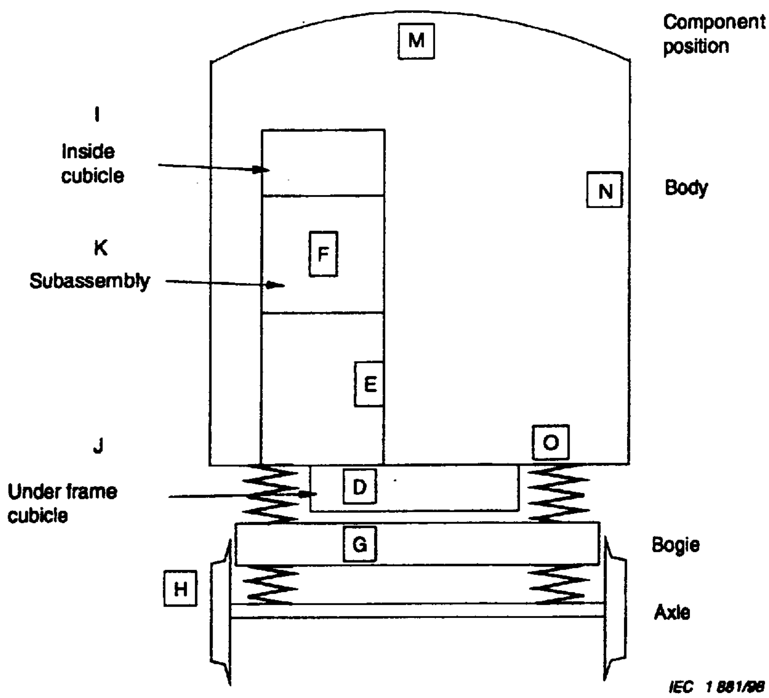
The first term in equation (B.10.2) represents the crest factor in test (which is limited by the testing machine) plus a quantity 0,5 to compensate for the tendency of response crest factors of SDOF systems to become higher than the excitation crest factors.

The second term represents the r.m.s. response amplitude (m/s^2) of an SDOF system, divided by Q, when excited by a broad band random vibration input, selected from the flat part of the relevant ASD spectrum for simulated long life testing in this standard.

Annex C
(informative)

Figure identifying general location of equipment on railway vehicles and their resulting test category

NOTE – These categories do not apply for vehicles with only one level of suspension.



Category	Location	Description of equipment location
1 Class A	M N O I and J	Components which are mounted directly on to or under the car body
1 Class B	D	Components mounted into an underframe cubicle which is in turn fixed to the car body
1 Class B	K and E	Components mounted into a large internal cubicle which is in turn fixed to the car body
1 Class B	F	Components mounted into subassemblies which are in turn mounted into a cubicle which is in turn fixed to the car body
2	G	Cubicles, subassemblies, equipment and components which are mounted on the bogie of a railway vehicle
3	H	Subassemblies, equipment and components or assemblies which are mounted on to the axle assembly of a railway vehicle

Figure C.1 – General location of equipment on vehicles

Annex D
(informative)

Example of a type test attestation

The following equipment has been tested to the requirements outlined in IEC 61373: Railway applications – Rolling stock equipment – Shock and vibration tests.

DESCRIPTION OF EQUIPMENT:

....

....

....

EQUIPMENT TYPE No. .... **MANUFACTURER'S NAME:** ....

....

....

ISSUE/MODIFICATION STATUS:................. **SERIAL No.** ....

....

....

TEST HOUSE REPORT No. .... **REPORT DATE:**..

....

....

PRODUCT TEST SPECIFICATION No.:

....

....

Comments:

....

....

....

1) Test house................................ Position............... Date...............

2) Manufacturer............................. Position............... Date...............

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE: When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60068-2-27	1987	Basic environmental testing procedures Part 2: Tests - Test Ea and guidance: Shock	EN 60068-2-27	1993
IEC 60068-2-47	1982	Part 2: Tests - Mounting of components, equipment and other articles for dynamic tests including shock (Ea), bump (Eb), vibration (Fc and Fd) and steady-state acceleration (Ga) and guidance	EN 60068-2-47	1993
IEC 60068-2-64 + corr. October	1993 1993	Part 2: Test methods - Test Fh: Vibration, broad-band random (digital control) and guidance	EN 60068-2-64	1994

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